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THE INFLUENCE OF BODY WEIGHT, TEMPERATURE AND SEASON UPON THE RATE OF OXYGEN CONSUMPTION OF THE TERRESTRIAL AMPHIPOD, TALITRUS SYLVATICUS (HASWELL)

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Talitrus sylvaticus, a soil-inhabiting amphipod, (Family Talitridae), is widely distributed in the coastal region of eastern Australia and is particularly abundant in the litter layer of sub-tropical rain forests in this region. The experiments described here were designed to obtain part of the data necessary to estimate the quantity of energy which would have been used during a year by a population of *Talitrus sylvaticus* in a tract of rain forest at Bulli Pass, N.S.W. A preliminary study was made of the relationship between the rate of oxygen consumption of *T. sylvaticus* and body weight. This was followed by a study of the effect of temperature on the rate of oxygen uptake of *Talitrus* in both summer and winter.

Methods

Large numbers of *T. sylvaticus* were brought from the rain forest at Bulli Pass at regular intervals and kept in the laboratory in jars of leaf litter and soil at room temperature. Animals which had been in the laboratory longer than a month were not used in the experiments.

Rates of oxygen consumption were measured in a Warburg respirometer, the temperature of the water bath being controlled to within ± .01 of a degree. The volumes of the reaction vessels ranged from 3 to 4 ml.

The *Talitrus* used in any vessel were weighed *en masse,* then dropped into the vessel where they remained quietly on, or close to, two strips of moistened filter paper of known area which had been placed in the bottom of the vessel. In all experiments the vessels contained between 80 and 120 milligrams live weight of *Talitrus* and 0.8 ml. of 10 per cent KOH as an absorbent for CO_2. After each experimental "run" the animals were removed from the vessels and discarded.

Experimental Results

The effect of body weight at 25° C.

Figure 1 shows the relationship between the rate of oxygen uptake of *T. sylvaticus* and body weight at 25° C. The curve, fitted to the scatter of points by

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use of a double logarithmic regression, has the formula:

$$y = 533\, x^{-0.164},$$

where y is the rate of oxygen uptake in $mm.^3$ O_2 per gm. per hour, and x is the body weight in milligrams. The rate of oxygen uptake, expressed as microliters of oxygen used per animal per hour by multiplying the right hand side of the above equation by x/1000, gave the formula:

$$y = 0.533\, x^{0.836}.$$

The effect of temperature

The relationship between the rate of oxygen uptake of *Talitrus* and temperature is illustrated by Figure 2. Figure 2 also shows the effect of the body weight

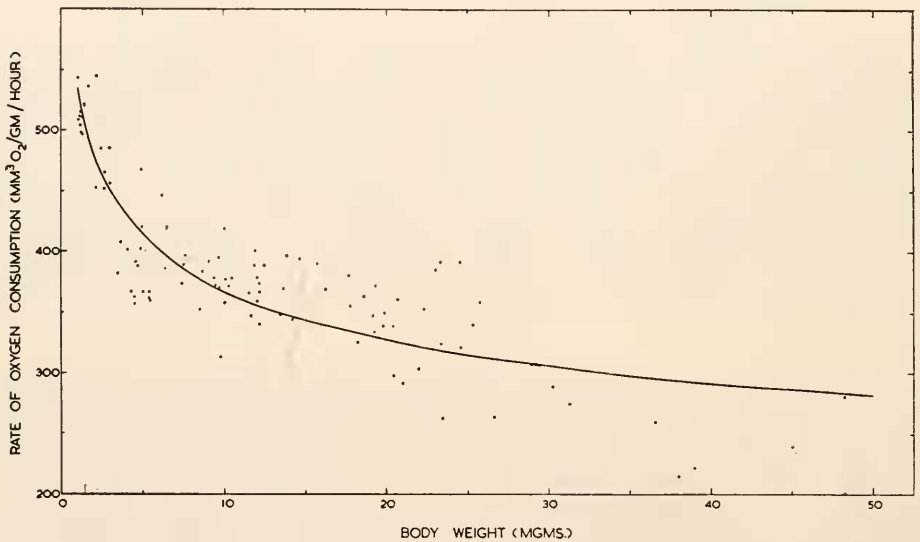

FIGURE 1. The relationship between the rate of oxygen consumption of *Talitrus sylvaticus* and body weight at 25° C.

of the animals (graphs A, B and C), and the effect of season on the rate of respiration of *Talitrus* over a range of temperatures.

A comparison of the graphs in rectangles A, B and C of Figure 2 shows that the rate of oxygen uptake of small *Talitrus* (mean body weight 1.5 mg.), was higher than that of medium and large animals (mean body weights 8.5 mg. and 21 mg., respectively), at temperatures above 15° C. The increase in the respiratory rate of the smallest animals, with increasing temperature, was more rapid than the corresponding increase in that of the largest animals. For example, between 20° C. and 30° C. the Q_{10} of *Talitrus* of mean body weight 1.5 mg. was 2.33 in winter while the Q_{10} of *Talitrus* of 21 mg. mean body weight was 1.66 in winter.

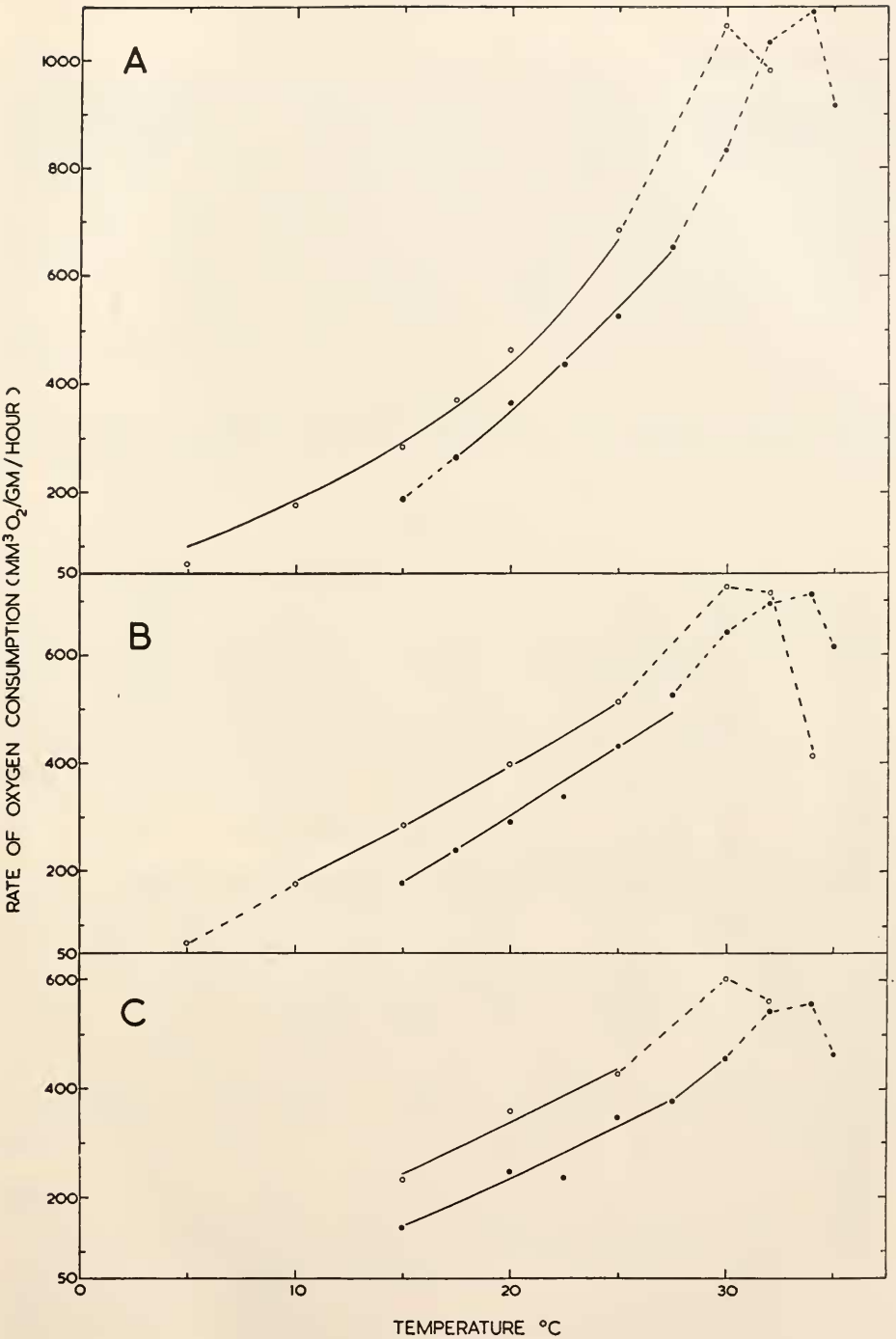

FIGURE 2. The relationship between the rate of oxygen consumption of *Talitrus sylvaticus* and temperature. Graphs A, B, C show curves for the rate of oxygen consumption of *Talitrus* weighing 1.5 mg., 8.5 mg. and 21 mg., respectively. Open circles, winter; black dots, summer. Broken lines are shown where the curves do not fit a logistic formula.

The effect of season

At any temperature the rate of oxygen consumption of *Talitrus,* which were taken from the field in winter, was approximately one and a half times higher than that of *Talitrus* of the same body weight which were taken from the field in summer. For example, the rate of oxygen uptake of *Talitrus* weighing 1.5 mg. was 187 mm.^{3} O_2 per gm. per hour at 15° C. in summer, and 272 mm.^{3} O_2 per gm. per hour at the same temperature in winter. Figure 2 shows that the rate of oxygen consumption of *T. sylvaticus* at any temperature in winter was the same as that at a temperature 2.5 centigrade degrees higher in summer.

An analysis of variance of these results showed that, of the factors influencing the rate of oxygen consumption of *T. sylvaticus,* significant first order interactions occurred between temperature and body weight, temperature and season, and season and body weight, P being less than .01 in each instance. The analysis also showed a significant second order interaction between temperature, body weight and season of the year upon the rate of oxygen uptake of *Talitrus,* ($P < .01$).

Discussion

The decrease in the rate of respiration of *Talitrus sylvaticus* relative to increase in its body weight at 25° C., as expressed by the exponent of 0.836, agrees well with previous results found on the respiration of crustaceans. Weymouth *et al.* (1944) found that the relationship between the rate of oxygen uptake and body weight of the kelp crab, *Pugettia producta,* was expressed by an exponent of 0.798 at 15° C. Scholander *et al.* (1953) found that an exponent of 0.85 could be applied to this relationship in many crustaceans ranging from the arctic fairy shrimp, *Branchinecta paludosa,* to the tropical giant land crab, *Sesarma ricordi.* Zeuthen (1953), in his review of the subject of body size and metabolic rate in organisms, stated that an exponent of 0.80 described this relationship for crustaceans containing more than 0.1 milligrams of body nitrogen.

The occurrence of a seasonal adaptation of the rate of oxygen uptake, as shown by *Talitrus sylvaticus,* has only been found infrequently in invertebrates (Scholander *et al.,* 1953). Edwards and Irving (1943a) found that the rate of oxygen uptake of the sand crab, *Emerita talpoidea,* from beaches at Woods Hole, Mass., was higher in winter than in summer at all temperatures below 20° C. In contrast, the amphipod, *Talorchestia megalophthalma* (family Talitridae), which also inhabits the beaches at Woods Hole, hibernates in winter and the rate of its respiration is the same in winter as in summer (Edwards and Irving, 1943b). Seasonal adaptation of metabolic rate to changing environmental temperatures has also been recorded in the gill tissues of the clam, *Venus mercenaria* (Hopkins, 1946).

The mean monthly temperature in the rain forest litter at Bulli Pass in 1951 ranged from 12.0° C. in July (mid-winter) to 21.0° C. in January (mid-summer) (Clark, 1954). The shift in the O_2 consumption-temperature curve of *Talitrus sylvaticus* to the left only covered a distance of 2.5 centigrade degrees along the abscissa (temperature axis in Fig. 2) and the R.Q. of *Talitrus* remained the same in summer and winter (Clark, 1954), so that its energy output was lower in winter than in summer.

The physiological mechanism which enables animals to alter their rate of oxygen consumption in response to season is unknown. Hopkins' (1946) demonstration of seasonal adaptation in the excised gill tissues of *Venus mercenaria* suggests that seasonal adaptation occurs within the tissues of the animal and hence may be effected by changes in the concentration of intracellular respiratory enzymes.

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Summary

1. The relationship between the rate of oxygen consumption and body weight of the terrestrial amphipod, *Talitrus sylvaticus,* was expressed by an exponent of 0.836 at 25° C.

2. The rate of oxygen consumption of *Talitrus sylvaticus* was significantly higher in winter than in summer at any one temperature.

3. Analysis of variance showed that, of the factors influencing the rate of oxygen consumption of *T. sylvaticus,* first order interactions occurred between temperature and body weight, temperature and season, and season and body weight. There was also a significant second order interaction between temperature, body weight and season on the rate of oxygen uptake of *T. sylvaticus.*

4. The adaptation of its rate of oxygen uptake by *Talitrus sylvaticus* to seasonal differences in temperature was not sufficient to enable it to maintain the same rate of output of energy in winter as in summer.

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